Defining the End of the Post-Closure Monitoring Period

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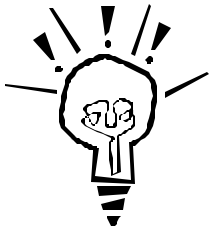
Introduction

- How to define the end of the post-closure monitoring period?
  - traditional landfills
  - leachate recycle/bioreactors



Introduction

- In the US, the post-closure monitoring period is 30 years unless it is extended by the governing regulatory agency
  - technical criteria are lacking and needed:
    - to reduce, extend or modify the monitoring period

Career Objective

- Develop and implement a protocol that will make it possible to determine when post-closure monitoring can be reduced or stopped

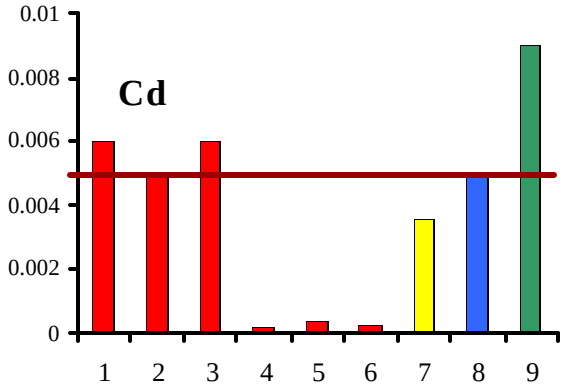
Factors to Consider in Long-Term Monitoring

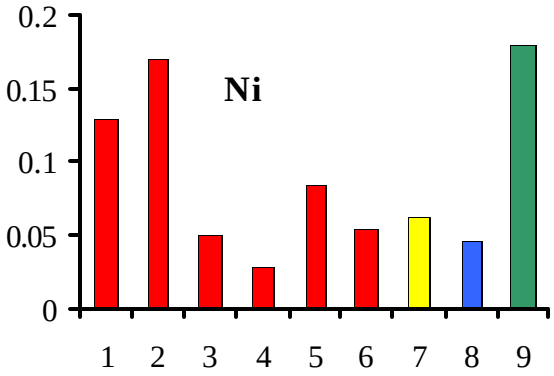
- Leachate composition
- Leachate production
- Leachate release to surface and ground water
- Gas production
- Geotechnical characteristics

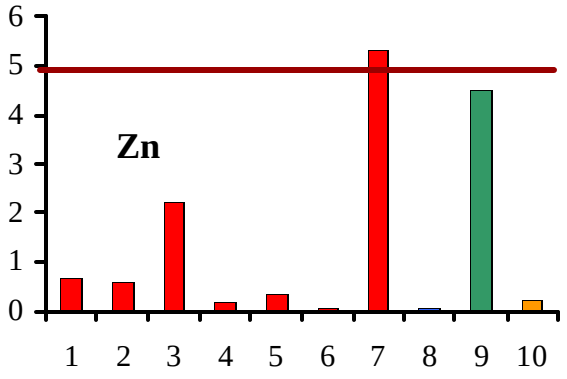
Leachate Composition

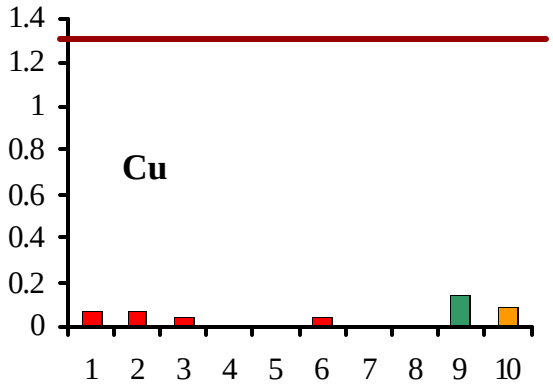
- Numerous publications on long-term leachate quality
- Organic strength → BOD:COD ratio < 0.1
  - necessary but not sufficient
- Nutrient concentration
  - high ammonia is typical

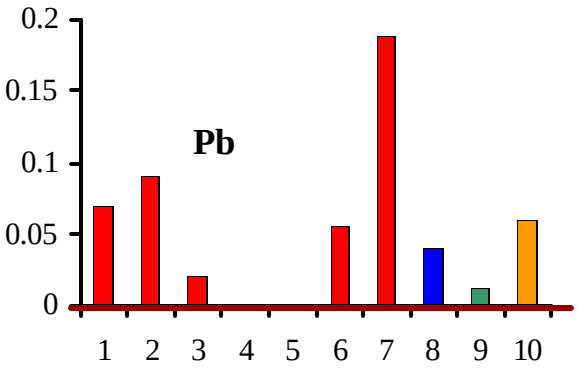
Metals: Drinking Water Quality

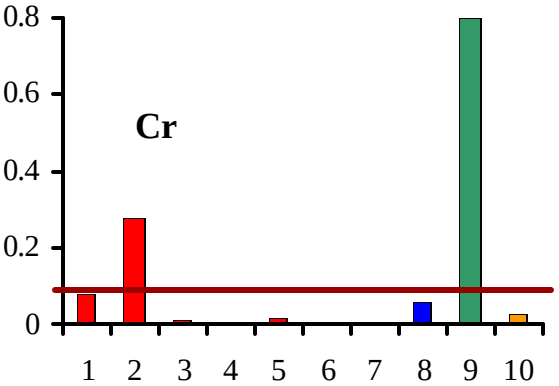












Leachate Composition: Trace Organics

- Simple model (MOCLA) suggests volatiles are released in gas within a decade
- Data on long-term trends for trace organics are needed
- Slow desorption will not lead to concentration increases -- so trends should be lower

Leachate Composition

- Bulk organics (BOD &COD)
- Ammonia
- Metals
- Trace Organics

Leachate Quantity

- How much leachate can be expected and how will it be managed?
- Quantity
  - field studies/data from double-lined landfills
  - calculation based on efficiency
  - calculation based on defect density

Leachate Quantity: Calculation

- 100-acre (40.5 ha) site receiving 40 in (100 cm) ppt/yr @ 99% collection efficiency
- BOD:
  - 10 mg/L = 4.5 mg/acre/day (11.1 mg/ha/day)
- COD
  - 100 mg/L = 45 mg/acre/day (111 mg/ha/day)
- NH_3-N
  - 750 mg/L = 341 mg/acre/day (843 mg/ha/day)

Leachate Quantity

- Field data: 0.5–22 gal/acre/day (4.7–206 L/ha/day)
- 7–3 mm holes/acre = 0.14 gal/acre/day (1.3 L/ha/day)
- 99% collection efficiency: 0.12 gal/acre/day (1.12 L/ha/day)
- 99% efficiency can be achieved

Environmental Impacts of a Leachate Release

- Water quality modeling
  - release of leachate to the environment is worst case
  - study environmental impact for assumed leachate and receiving stream characteristics using a dissolved oxygen depletion model
    - focus on BOD, NH_3-N and dissolved oxygen

Groundwater Quality

- The leachate O_2 demand when released at 10.7 gal/ac-day [100L/(ha-day)] with 250 mg-N/L cannot be met by an aquifer, even with a high saturated thickness (65.6') and a high transport velocity (0.33 ft/d)
  - lack of perfect mixing will further limit plume degradation
  - this suggests that a 10.7 gal/ac-day release to the subsurface will likely be unacceptable

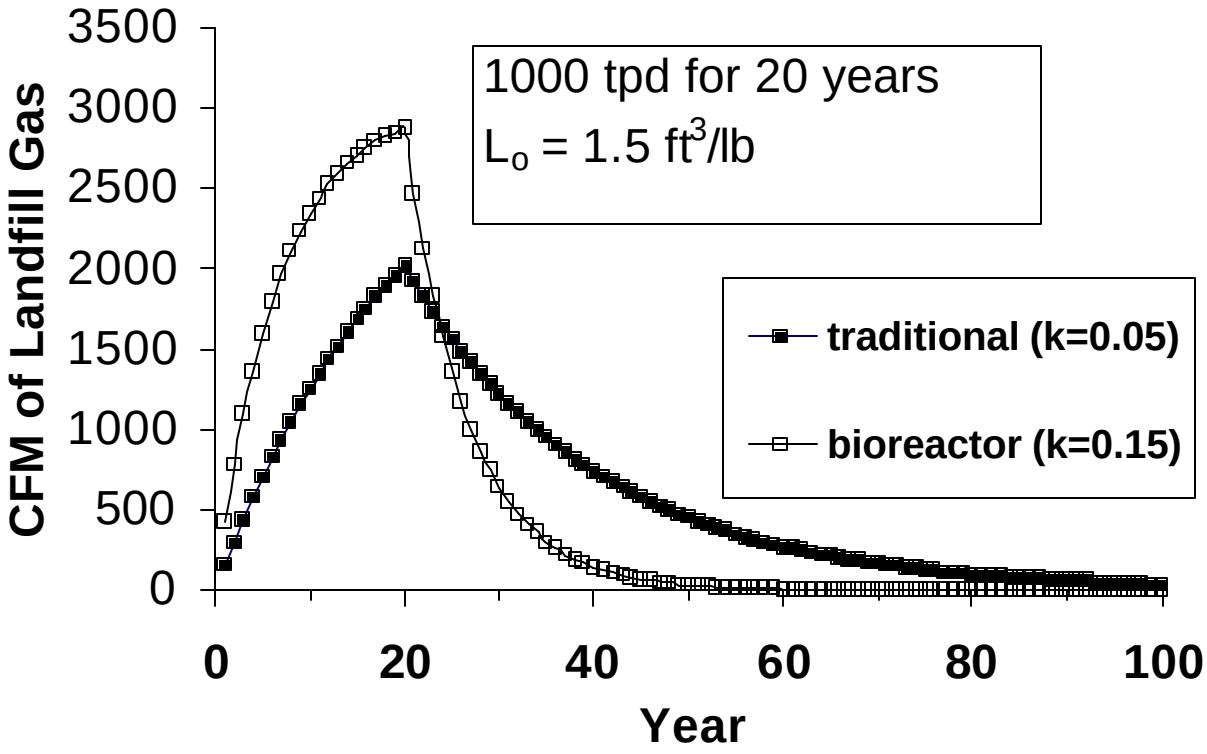
Groundwater Quality

- Monitoring Strategy and Trace Organics
  - BTEX and CAHs are compounds of greatest concern
    - CAHs degrade anaerobically - in landfill
    - BTEX degrade readily under aerobic conditions
  - A leachate release will likely drive an aquifer anaerobic
  - Monitor DO!

Gas Production

- Quantity of gas produced at end of post-closure monitoring period
- When can a landfill go from active collection to passive venting?

Methane Production in Traditional and Bioreactor Landfills



Criteria

- Explosion hazards and VOC migration
  - monitor vadose zone for ??? years after turn off an active gas collection system
- Odor problems
  - are there complaints after deactivation of a landfill gas collection system?
- Mass emissions
  - Regulatory guidance and constraints

Geotechnical Stability

- Trends in settlement data could be used to evaluate whether additional settlement is expected.
  - should a post-closure termination request include settlement data?
  - data could be used to evaluate cover inspection schedule.

Proposed Approach

- Evaluate site-specific impacts using a modular/flexible approach
  - leachate mass release rates
    - is leachate present in the collection system?
    - Are there seeps?
    - what is its composition and quantity?
  - identify receiving body to evaluate impact

Proposed Approach

- Gaseous emissions
  - are odors a problem?
  - is their evidence for gas migration?
- Cover stability
  - evidence that settlement is complete

Summary

- Is monitoring ever really finished??
  - perhaps what changes is the monitoring frequency or the components of the landfill to be monitored
    - cover
    - leachate production
    - gas migration

Ongoing Work

- Detailed protocol development and case studies
- The focus is potential **environmental impact**

Divide and Conquer

- Separate evaluation for:
  - leachate
  - gas
  - cover
  - groundwater

Divide and Conquer

- Verification Monitoring
  - are concentrations below a standard?
  - are changes to current control mechanism(s) justified?
- Surveillance Monitoring
  - Geometrically reducing sampling/inspection program
- Implement End Use

Leachate Evaluation

- Is the mass flux increasing or decreasing?
  - If decreasing, are concentrations suitable for direct release (i.e. drinking water standards)?
    - **yes**: verification monitoring, followed by geometrically reducing surveillance monitoring
    - **no**: is mass release to receiving body acceptable (i.e. dissolved oxygen depletion model)?
      - **yes**: verification monitoring, followed by geometrically reducing surveillance monitoring
      - **no**: risk assessment or continue post-closure monitoring

Case Studies

- Similar logic diagrams for gas, cover and groundwater
- If all impacts are acceptable, what must be done to maintain this situation?
  - cover inspection -- which is cheaper than groundwater monitoring
  - implement an end use that necessitates maintenance

Additional Reading

Kjeldsen, P.K. et al., 2002, “Present and Long Term Composition of MSW Landfill Leachate – A Review,” Critical Reviews in Environmental Science and Technology, 32, 4, p. 297 - 336.

Barlaz et al., 2002, A Critical Evaluation of Factors Required To Terminate the Post-Closure Monitoring Period at Solid Waste Landfills,” Environ. Sci. & Technol., 36, 16, p. 3457 - 64